of cosmical meteorology upon a satisfactory basis, entirely in harmony with the procedure marked out in previous papers.

While it can not be supposed that this discussion of the solar prominence frequency in longitude gives us final quantitative results on the rotation phenomena of various zones, yet the line of argument is sufficiently sustained to warrant further extensions of the research. We have shown that the solar angular velocity diminishes from the equator toward the poles at a certain rate, as on fig. 1 for example, or as on fig 4.

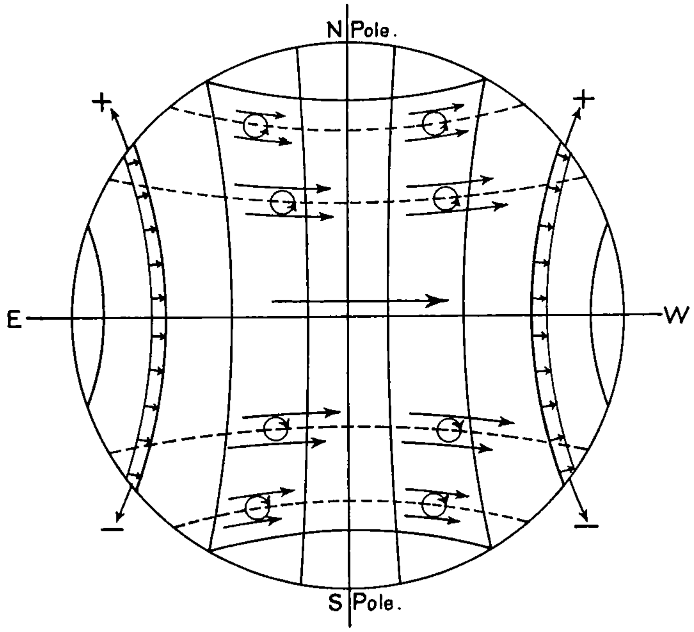

FIG. 4.—Formation of vortices in the solar mass by differential rotations.

This is in harmony with the von Helmholtz-Emden equations for a rotating mass hot at the center and cooling toward the surface.[16] In such a mass there are discontinuous concave cylindrical surfaces coaxial with the axis of rotation, the equatorial parts being nearer the axis than are the polar parts. This also implies that the polar regions of the sun are warmer than the equatorial by reason of the currents from the center toward the poles. At a surface of discontinuity, on each side of which the pressure is the same, but the temperature and angular momentum different, as where a rapidly moving current flows over a more slowly moving current in the earth's atmosphere, the conditions are favorable for forming vortex tubes, terminating on the surface, but extending through the mass of the sun. They are right-handed in the northern hemisphere and left-handed in the southern hemisphere, for convective actions from the equator toward the poles. If vortices are thus formed in the sun, so far as the state of its material permits, then the solar mass is in fact in a polarized state, the internal matter tending to rotate throughout the globe around such lines as are the generators of the required discontinuous surfaces. The turbulent conditions of internal circulation tend to a lawful disposition by the regulative action of a hot mass gravitating to a center by its own internal forces and emitting heat through these processes of circulation accompanied by polarization and rotating vortex tubes. The contents of a tube must be made up of molecules and atoms more or less charged with electricity, and the necessary rotatory motion produces Amperean electric currents which are a sufficient cause for the generation of a true magnetic field, positive on the northern and negative on the southern hemisphere of the sun. This conforms to the result reached years ago by my analysis of the terrestrial magnetic field, which showed that the earth appears to be immersed in a magnetic field perpendicular to the plane of the ecliptic and positive to the north of it. Variable circulation within the solar mass would display itself in corresponding changes in the rotation of the discontinuous surfaces, in the vortices carrying electrical charges, in the external magnetic field, in the number of prominences, faculae, and spots, in the earth's magnetic and electric fields, and in the terrestrial temperatures and pressures. Synchronism having thus been established throughout this vast complex cosmical system and referred back to fundamental thermodynamic and hydrodynamic laws, it becomes possible to make further advances in the problems of solar physics. Thus, the curvature of the internal lines can be studied in different parts of the meridian section on passing from the surface of the sun to internal parts by means of the vortex law of constant angular momenta, $\Omega = \omega \varpi^2$, under the assigned thermal conditions. We shall make an attempt to do this in a report which will contain the tabular data in full upon which these deductions are based.

If it is true that large cosmical cooling masses in rotation contain a polarized or vortical internal structure which is the basis of a magnetic field, then it follows that this is the explanation of the earth's magnetism as well as of the magnetism of the sun. Hence, all stars are magnetized spheres, and their relative magnetism would be a measure of the activity of their internal circulations. Thus, the relative intensity of the earth's and the sun's magnetization becomes a measure of the internal vortical circulation in polarized tubes, and the variations of the earth's magnetic field have a cosmical significance, not only as to the direct action of the sun as a great rotating variable magnet, but as a measure of the forces which go to make up the solar output in several manifestations of energy. The summary of this line of thought may be found in chapter 4 of my "Eclipse Meteorology." It is proper to renew my objection to the results derived by other investigators for any solar rotation period which is shorter than 26.68 days, because it does not seem to be possible in view of the above analysis of solar conditions. Thus, we must reject Spoerer, 26.32; Broun, 25.92, 25.86, and 25.83; Hornstein, 26.39, 26.03, 26.24, and 25.82; Liznar, 26.05 and 25.96; Müller, 25.66, 25.79, 25.86, 25.87, and 25.47; von Bezold, 25.84; Hamberg, 25.84; Ekholm and Arrhenius, 25.93; Schuster, 25.809 or 25.825. The numerous computations, giving results so widely different from that apparently ruling in the sun as derived from observations upon its own material, seem to indicate that the application of these several methods of computation to terrestrial data raises grave doubts as to their value. There are numerous difficulties in applying least square methods to solar-terrestrial data in the present state of our science. The great fluctuations going on within the solar mass tend to mask the fundamental law until it has been derived, at least approximately, by simpler methods. But the evidence is very positive that the equatorial period of 26.68 days is the shortest one actually prevailing in any portion of the mass of the sun.

CLIMATOLOGY OF COSTA RICA.

Communicated by Mr. H. PITTIER, Director, Physical Geographic Institute.

[For tables see the last page of this REVIEW preceding the charts.]

Notes on the weather.—On the Pacific slope the rainfall was generally less than the average, although enough to cause numerous slides along the few railways to the western coast. In San José pressure and temperature were above the normal and relative humidity slightly under it. Rainfall almost normal and unequally distributed through the month. Sunshine one hundred and seventy-nine hours against one hundred and thirty-six. The marked alternation of hot sun and violent showers caused a good deal of damage to the coffee crop, part of which has thus been "frozen" (helado). On the Atlantic

[16] See Eclipse Meteorology, pages 70 and 71.

side rainfall was almost everywhere moderate, although a few slides were reported from the C. R. Railroad in the valley of Reventazon.

Notes on earthquakes.—October 5, 2^h 13^m a. m., slight shock NE–SE., intensity II, duration 13 seconds. Also reported from Tres Rios.

A STUDY OF THE SUMMER FOGS OF BUZZARDS BAY.

By Mr. FRANK W. PROCTOR, dated Fairhaven, Mass., October 25, 1903.

Fog is moderately frequent in summer over Buzzards Bay on the south coast of Massachusetts. It occurs irregularly, without apparent system, and lasts for periods varying from a few hours to several days. There are no obvious weather changes immediately preceding the visitations of these fogs which might suggest their cause. The irregularity of their occurrence and duration make them an interesting study.

North of Cape Cod, in Massachusetts Bay, the water of the ocean quite to the shore is notoriously chilly; the fogs are popularly attributed to the cooling of moist air from the Gulf Stream by the Labrador current along the coast. But on the southern shore of Massachusetts the water is so much warmer that ocean bathing is comfortable in summer and there is little to suggest an arctic current.

Radiation, or ground fog, is rare here at this season, and breezes from the land are seldom cool enough to condense the vapor rising from the warm surface water of the bay. The fogs that commonly occur here in July, August, and September usually come with southwesterly winds, which are the prevailing winds of summer. These winds blow daily with much regularity, augmented by the sea breeze, and interrupted only by occasional errant highs and lows. But only a small percentage of these southwesterly winds, coming in cool from the ocean, are attended with fog, though the high temperature of the shallow waters of the bay and sounds, and the large vapor content of the lower air would seem to constitute conditions favorable to local condensation.

Every one knows that fog is condensed aqueous vapor. The requisite degree of saturation may be caused either by an increase of vapor pressure, or by a reduction of the temperature or by both in combination. In the absence of observations with thermometer and hygrometer it is impossible to know in what proportions these two factors contribute to produce a fog.

To fully understand the phenomenon of fog formation it is necessary to know the cause of the reduction of the temperature, and the source of the vapor increment. Since the cooling may come from radiation, conduction, adiabatic expansion, or mixture with cold air from elsewhere, and the added vapor may come from local evaporation or from moist air currents, it is not always a simple matter to determine how a fog has been formed. The problem becomes still more difficult when the fog to be studied has been blown inland from the sea where little is known of the mean conditions of water temperature and air moisture, and less concerning their daily fluctuations.

Moreover in most places fog occurrence is not periodic, but is so irregular as to be apparently without any system.

The Bay of San Francisco furnishes a particularly interesting case of periodic sea fogs which are thus described by Prof. A. G. McAdie in the MONTHLY WEATHER REVIEW, July, 1900, p. 284.

> With almost clocklike regularity in the vicinity of the Golden Gate on summer afternoons the velocity of the wind rises to about 22 miles per hour and through the gate comes a solid wall of fog, averaging 1500 feet in height, and causing a fall in the temperature to about that of the sea, namely 55°;[1] 1500 feet above, the air is clear and 20° or 30° warmer.

The fog photographs accompanying the text in Bulletin 31 are remarkably beautiful. In the interesting Fog Studies which are devoted to the consideration of these San Francisco Bay fogs,[2] Professor McAdie concludes:

> It is more probable that condensation is the result of the sharp temperature contrasts at the boundaries of certain air currents having different temperatures, humidities, and velocities, and that the contours of the land play an important part in originating and directing these air currents. The summer afternoon fogs of the San Francisco Bay region are then probably due to mixture more than radiation or expansion.

The summer fogs of the east coast of Massachusetts have been studied by Clayton. He concludes that they are due to the flowing of a warm, damp, air current from the south over a very cold westward current off the water.

> Intermixture of these two currents goes on until they are churned to the bottom.[3]

Neither of the foregoing explanations of fog formation seems to suit the case of the summer fogs of Buzzards Bay. Here there are no hills or mountains as around San Francisco, and there is no crossing of air currents as observed by Clayton on the east coast of Massachusetts.

On fog days both the upper and lower winds blow from substantially the same direction, viz, southwesterly.

In order to study these fogs, the writer, during the summers of 1901 and 1902, made tri-daily observations of temperature, moisture, barometric pressure, wind direction, and velocity, and noted every case of fog formation, except when asleep at night. The station of observation is on Sconticut Neck, which extends southward into Buzzards Bay on the east side of New Bedford Harbor.

It early became apparent that there is a relation between the air pressure and the appearance of fog, and the completed records for the two seasons show that there was no instance of fog when the controlling conditions were anticyclonic. This, in part, explains why these fogs as a rule form only when the wind is southwesterly and not when equally cool ocean winds come in from southeast and south. As long as the winds come from southeast and south the conditions are at this season usually anticyclonic, and the air is too dry for fog. By the time the wind has veered to southwesterly the pressure and circulation have usually become either normal or characteristic of an approaching cyclone.

In summer there is usually a haze over the water which looks like an inland summer haze, but here it is evidently of aqueous origin, for it is found when the winds are from seaward. It is of variable tenuity, but in ordinary fair weather it is generally dense enough to make the bluffs of the Falmouth shore, 11 miles across the bay, invisible from this station. It is in fact thin fog, though we are not accustomed to call visible aqueous vapor in the air fog until it is dense enough to eclipse objects near at hand. In making entries of fog observations it is often difficult to decide whether this veil over the water should be called fog or haze; one grades into the other insensibly.

The descending dry air of a passing anticyclone always dissipates this haze, leaving the air beautifully transparent, and brings clearly to view single houses on the Falmouth shore. The contrast is very striking. At such times the sky is sometimes entirely overcast with high stratiform clouds, mostly strato-cumulus, apparently showing that the descending air is confined to the lower strata. This entirely clear condition of the air is always of short duration. The haze persistently returns, and is present much the larger part of the time. The psychrometer also shows that the normal condition on shore here during July, August, and September is one of high absolute humidity favorable to fog formation, occasionally and briefly interrupted by anticyclonic dry air, but ordinarily the amount of vapor falls a little too short, and the temperature holds a little too high to permit the intense condensation called fog. For the two seasons, during the periods of observation, the percentage of foggy days in the ordinary sense was 21.5. This normal condition of high humidity, however,

[1] Weather Bureau Bulletin No. 31, p. 32.

[2] Weather Review, August and November, 1900, and January, 1901.

[3] Weather Bureau Bulletin No. 31, p. 35.